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ESTI CONTROL NR. **AL#-41612**CY NR. 7 OF 1 CYS**Group Report****1964-40****H. E. Frachtman****Haystack Pointing System: Sun****29 July 1964**

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

HAYSTACK POINTING SYSTEM: SUN

H. E. FRACHTMAN

Group 62

GROUP REPORT 1964-40

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MASSACHUSETTS

ABSTRACT

This memorandum describes the method used by the Haystack pointing computer program for obtaining the celestial coordinates of the SUN at any time.

Accepted for the Air Force
Franklin C. Hudson, Deputy Chief
Air Force Lincoln Laboratory Office

I. INTRODUCTION

SUNTRACK is a program in the Haystack Univac 490 pointing system whose output is the celestial coordinates of the Sun at a given time. The program computes the coordinates by 3rd difference interpolation in the tables of the apparent right ascension, declination, and radius vector of the Sun published in The American Ephemeris. The rates of change of the three quantities are computed by numerical differentiation.

II. INPUTS TO PROGRAM

A. Inputs Furnished by Core Memory

The program uses the registers listed in Table I for input information. The year and day are used to select the appropriate entries from the Sun's ephemeris. The coordinates of the Sun are interpolated for the time which is the sum of the times in CELTIME AND DELTATEE.

B. Inputs Furnished by Magnetic Tape

The tape format of the Ephemeris for the Sun, which has been edited and recorded by a 7094 program described in Reference (1), is shown in Fig. 1. Each block of 288 words covers a period of 32 days. The ephemeris for each day required 9 words. The program does not make use of the semi-diameter or the year-month-day words in the block. The tape must be on Unit 1 (normally Servo B).

III. PROGRAM OUTPUTS

A. Outputs Left in Core Memory

The apparent celestial coordinates of the Sun, corresponding to the time in the register CELTIME, together with their numerical derivatives, are stored in the appropriate registers, as illustrated in Table II.

B. Typewriter Outputs

During initialization the SUNTRACK program will type, using the INTERCOM sub-routine, certain information concerning the SUN. Items printed are:

<u>Register</u>	<u>Contents and Scaling</u>
W(CELTIME)	Days B28
W(DELTATEE)	Days B28
U(YEARMONTH)	Year B15 (4 decimal digits)
L(YEARMONTH)	Month B0
L(DAY)	Day of Year B0

TABLE I
Core Memory Inputs to SUNTRACK Program

NOTE: Notation "B28" means that the binary point is to the right of bit 28.

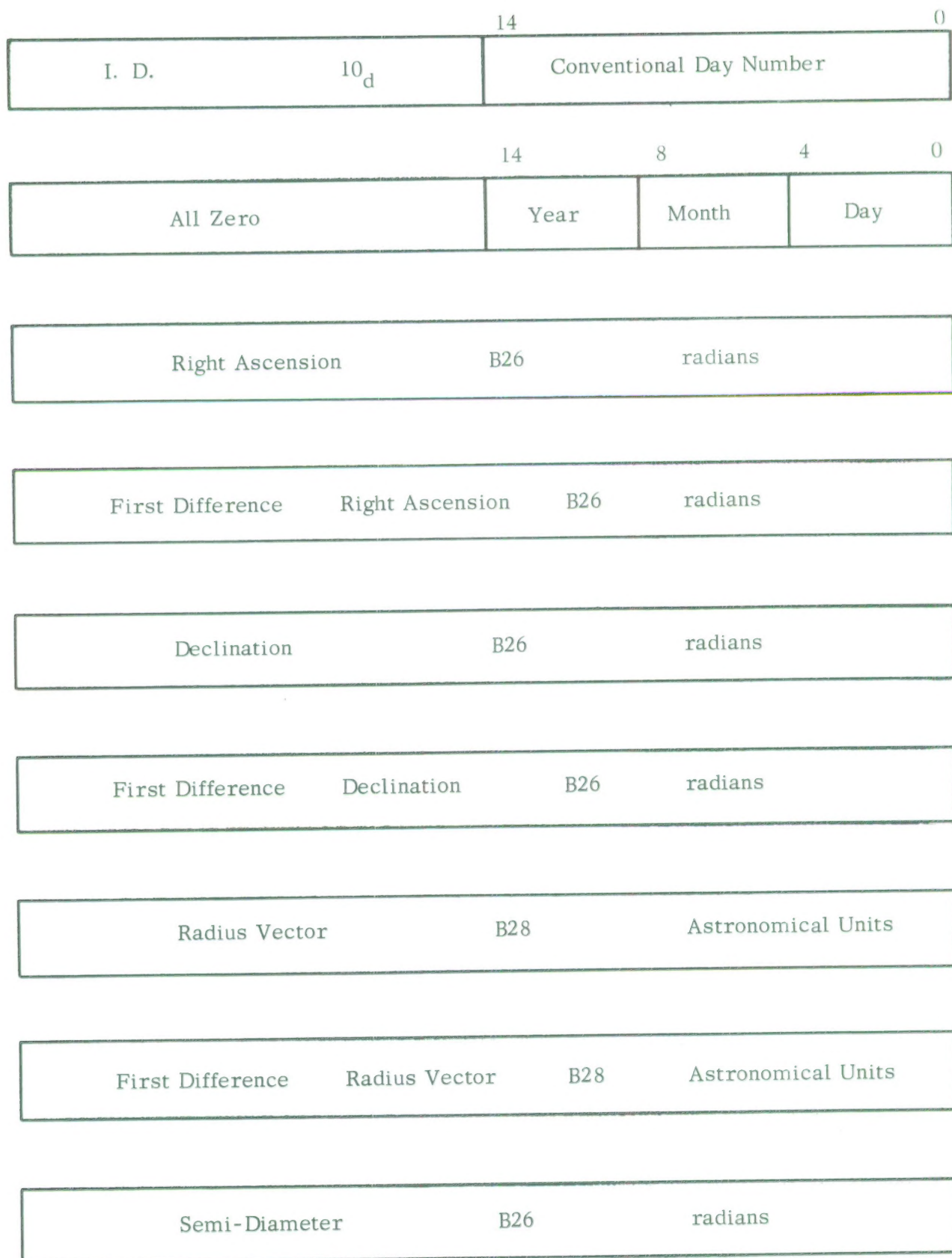


Fig. 1. Magnetic Tape Format for SUN Ephemeris

W(RA)	Apparent Right Ascension B27 in revolutions
W(DEC)	Apparent Declination B27 in revolutions
W(RADIUS)	One's complement of distance from center of earth to surface of Sun B24 in Astronomical units
W(RADOT)	Numerical Derivative of Right Ascension B37 radians/sec.
W(DEC DOT)	Numerical Derivative of Declination B37 radians/sec.
W(RADIUS DOT)	Numerical Derivative of Radius Vector B24 nautical miles/sec.

TABLE II

Core Memory Outputs of SUNTRACK Program

1. Julian Day corresponding to values in YEARMONTH, DAY, and CELTIME (7 digits).
2. Apparent Right Ascension of SUN (Hours, Minutes, Seconds to hundredths).
3. Apparent Declination of SUN (Degrees, Minutes, Seconds to hundredths).
4. Day of Year (Up to 3 digits).
5. Universal Time for which the coordinates are interpolated. It is the time in CELTIME at initialization (Hours, Minutes, Seconds to hundredths).
6. The distance between the centers of the Earth and Sun (Astronomical Units to hundred millionths).
7. The work "SUN".

If, after a search through 9 files on Unit 1 (or the finding of an end of tape mark), the sun ephemerides are not found, the program will type "SUN EPHEMERIS FOR X/Y NOT AMONG FIRST 9 FILES" and will exit to the master control program error return. "X" and "Y" indicate the current month and year, respectively.

If there is a tape servo malfunction during search, the program will type "IIC STATUS S1 ZZ" and will exit to the master control program error return. The two digit octal number "ZZ" comes from the tape status word and indicates the error condition.

IV. ASTRONOMICAL SIGNIFICANCE

The apparent right ascension and declination of the SUN in the ephemerides are referred to the true equinox and equator of date and are corrected for planetary aberration. They are geocentric apparent quantities; the parallax correction is made by the coordinate conversion program (COCON) in the Haystack system. The values in the tables are computed for Ephemeris Time as argument. The equation

$$ET = UT + \Delta T$$

is used to convert from Universal Time to Ephemeris Time. The constant ΔT , represented by the number in the register DELTATEE is approximately 35 seconds.

The radius vector is the actual geometric distance in astronomical units between the centers of the Earth and Sun at the stated time.

The number 934.91 is used to convert astronomical units per day to nautical miles per second in the computation of the number in RADIUSDOT.

$$934.91 = \frac{499.005 \times 2.997925 \times 10^5}{1.852 \times 86400}$$

499.005 = number of seconds per astronomical unit

2.997925×10^5 = velocity of light in kilometers per second

1.852 = kilometers per nautical mile

86400 = seconds per day

A comprehensive explanation of the ephemerides is given in Reference (2).

V. PROGRAM DETAILS

The SUNTRACK program is a subroutine of the Haystack Univac 490 pointing program. The initialization section begins at SUNINIT, the working section at SUNCONT. There are several closed subroutines within SUNTRACK. These are: DAYFIND, STATUSCK, INTERPOL, LEFRNDOFF, and ROUND OFF. A listing of the program is given in Appendix I.

A. Initialization

The program, upon initialization, stores an RIL instruction in the tape channel internal interrupt register and an RJP STATUSCK instruction in the external interrupt register. The area in core into which the tape data will be read is cleared, together with some additional registers. This is done to make diagnosis easier in case of malfunction.

The SUN Ephemeris entries are serially numbered by the program which generates the magnetic tape (Reference 1). These serial numbers are called "Conventional Day Numbers" (CDN). An arbitrary decision was made to produce and use tapes such that the CDN for 25 April 1963 is zero. The tape search process looks at the first word in each block, therefore, the SUNTRACK program must compute the CDN of the first word of the block containing the entry for the required day.

Using as inputs the year, day of year, and the effect of integral and half-integral values of CELTIME, the program computes the Julian Day number for the typewriter. The ephemerides start and run continuously from 25 April 1963, which has a Julian

Day Number of 2438144.5; this number is subtracted from the computed Julian Day number to find the Conventional Day Number. (It is 6 for 1 May 1963, the first day for which ephemerides tapes were made for the system.)

The first CDN in each block will be given by $6 + 32n$ where n is a positive integer or zero. The first CDN in a block is stored in TAPEBLOCK (lower half) and the SUN identification number 10_d is added to generate a tape search comparison word, stored in TAPESearch and also in SAFE.

The number in SLOTBLOCK represents the number of the entry in the 32-word block.

If $1 < \text{SLOTBLOCK} \leq 29$, only one block need be read in; if not, either the preceding or following tape block should also be read to provide sufficient ephemerides for 3rd order Bessel interpolation for a four-day period.

If the one-or two-block search and read operations are successful, control is regained at NORMAL and the tape is rewound without interrupt or interlock. At this time, SUN ephemerides for either 32 or 64 days are in core memory.

Besselian interpolation of right ascension is done by the INTERPOL subroutine and the interpolated result is converted to hours, minutes, and seconds and stored for type out. Declination and distance are then interpolated and stored for type out. The other quantities which are to be typed out by INTERCOM are set up. Control is transferred to INTERCOM 7 times for the seven line type out, which completes operation of the initialization section of SUNTRACK.

B. Working Section

The SUNTRACK working section begins at SUNCONT. Control is transferred to the subroutine DAYFIND which selects the day's ephemeris entry, stores the addresses of the table entries, and computes the interpolation argument P from the given value of CELTIME. The INTERPOL subroutine is then entered three times for the interpolation of right ascension, declination, radius and their time rates. An amount corresponding to the SUN's radius is subtracted from the interpolated value for accurate radar range

control. All values are converted, scaled and stored properly in core memory and control is transferred to the master control program.

C. Subroutines

The initialization section of the SUNTRACK program makes use of the INTERPOL, DAYFIND, STATUSCK, LEFRNDOFF, and ROUNDOFF subroutines. The working section uses all except STATUSCK.

1. INTERPOL

The SUNTRACK interpolation subroutine uses Bessel's interpolation formula (Reference 3) for 3rd difference interpolation of the ephemeris. The formula is

$$f_P = f_0 + P\delta f_{1/2} + \frac{P(P-1)}{4} [\delta^2 f_0 + \delta^2 f_1] \\ + \frac{P(P-1)(P-1/2)}{6} \delta^3 f_{1/2}$$

The quantities in the formula are associated with computer registers as follows:

- a. The address of f_0 is in index register 4.
- b. The interpolation argument P is in register P.
- c. $\delta f_{1/2}$ is in register GAMMA.
- d. $P(P-1)$ is in register PSQMP.
- e. $\delta^2 f_0 + \delta^2 f_1$ is in register DMINB.
- f. $\frac{P(P-1)}{6}$ is in register PSQMP6.
- g. $\delta^3 f_{1/2}$ is in register DMIN2CPLB.
- h. f_P is in the A register at the finish.

The subroutine also performs numerical differentiation using the following formula (Reference 3):

$$hf'_P = \delta f_{1/2} + \frac{2P-1}{4} [\delta^2 f_0 + \delta^2 f_1] \\ + \frac{3P^2 - 3P + 1/2}{6} \delta^3 f_{1/2}$$

At the completion of the subroutine, hf'_P is stored in the register NUMDERIV.

When the subroutine is entered, Index Register 4 contains the address of f_0 and the register SETINTAD contains the address of $\delta f_{1/2}$ of the quantity to be interpolated. Index register 3 is used to acquire the other two first difference registers.

2. DAYFIND

The DAYFIND subroutine computes the addresses of the ephemeris entries corresponding to the current day. It also computes the interpolation argument P by properly scaling the sum of CELTIME and DELTATEE. The value of P is always positive, even though time be set negative by the system control programs. The number in DAYINDEX, which can be -2, -1, 0, or +1, takes account of the effect of the integral part of CELTIME on the selection of ephemeris entry.

3. STATUSCK

The STATUSCK subroutine is entered from the external interrupt register associated with the tape channel when the interrupt occurs. Examination of the status code generates four possible outcomes:

- a. If the code indicates a normal completion (40), control is returned to the program at the interrupted point.
- b. If the code indicates that an end of tape mark was sensed, the tape is rewound and a message indicating failure to find the ephemeris is printed by the typewriter. The message is described in Section III B. Control is passed to the error return of the master control program.
- c. If the code indicates that an end of file mark was sensed, the register IMPERIAL is indexed and tested for the value 9. When less than 9, the next file is searched by passing control to TRYAGAIN. When IMPERIAL equals 9, an end of tape condition is assumed and the action is as described in (b) above.
- d. If the code indicates anything but end of file, end of tape, or normal completion, a tape error has occurred. The message described in Section III B, indicating the type of error is printed by the typewriter and control is passed to the error return of the master control program.

4. LEFRNDOFF

The LEFRNDOFF subroutine left shifts the AQ register the number of places indicated by the contents of index register 5 and rounds the A register

5. ROUND OFF

The ROUND OFF subroutine right shifts the AQ register the number of places indicated by the contents of index register 5 and rounds the A register

APPENDIX I

SPURT OUTPUT NO. 210

FRACHTMAN*7/14/64

CARDS	LI	ID	LABEL	TA	STATEMENT	SUNTRACK	LOC	F	JKB	Y	NOTES
	00000		SUNTRACK	PROGRAM	FRACHTMAN*7/14/64						
	00001		SOLAR	EQUALS	100		00000	00177	00002		
	00002		MONTAPE	EQUALS	55		00001	30322	32514		
	00003		TAPEINPUT	EQUALS	35		00002	61000	00000		
	00004		EPHEM	MEANS	C15*		00003	11030	00766		
	00005		HENRY	U-TAG	SUNCØNT*SUNINIT		00004	15030	00055		
	00006			FD	1*SUNP		00005	11030	00767		
	00007		SUNINIT	ENTRY			00006	15030	00035		
	00008			ENT	A*(IGNØRE)		00007	12400	01555		
	00009			STR	A*(MØNTAPE)		00010	11000	00000		
	00010			ENT	A*(INTERUPT)		00011	15034	01413		
	00011			STR	A*(TAPEINPUT)		00012	72400	00011		
	00012			ENT	B4*877D		00013	11020	63147		
	00013			CL	A*		00014	21000	03651		
	00014			STR	A*(YRREMAIN+B4)		00015	15030	00746		
	00015			BJP	B4*ERASE		00016	03000	00036		
	00016		ERASE	ENT	A*(YEARMØNTH)		00017	23000	00004		
	00017			SUB	A*1961D		00020	15030	01413		
	00018			STR	A*(MØNTHPRINT)		00021	22000	02665		
	00019			RSH	AQ*30D		00022	14030	01414		
	00020			DIV	4		00023	10030	01413		
	00021			STR	A*(YRREMAIN)		00024	22000	00555		
	00022			MUL	1461D		00025	34030	01414		
	00023			STR	Q*(WHØLEYEAR)		00026	65000	00274		
	00024			ENT	Q*(YRREMAIN)		00027	10030	01417		
	00025			MUL	365D		00030	05000	00005		
	00026			RPL	Y+Q*(WHØLEYEAR)		00031	26000	00006		
	00027			RJP	DAYFIND		00032	26030	00771		
	00028			ENT	Q*(TAPEBLØCK)		00033	14130	01430		
	00029			LSH	Q*5		00034	10030	01430		
	00030			ADD	Q*6		00035	14030	01421		
	00031			RPL	Q*(IDENT)		00036	10000	00035		
	00032			RJP	Q*(SAFE)*SKIP		00037	11000	00001		
	00033			ENT	Q*(SAFE)		00040	04430	01420		
	00034			STR	Q*(TAPESEARCH)		00041	61000	00510		
	00035			ENT	Q*29D		00042	73670	00541		
	00036			ADD	A*1						
	00037			STR	AQ*(SLØTBLØCK)*YIN						
	00038		TRYAGAIN	ENT	NØTIV						
	00039			ENT	EPHEM*(EPHEMØ)						
	00040			COM							
	00041			JP							
	00042			IN							
	00043										
	00044										
	00045										
	00046										
	00047		BLØCKBEE								

1ST TEMP STORAGE

(0,1,2,3)
DAYS IN 4 YRS

FRACHTMAN*7/14/64

CARDS	LI	ID	LABEL	TA	STATEMENT	SUBTRACK	LUC	F	JKB	Y	NOTES
-	00050				NØ-ØP		00043	12000	00000		
-	00051				EX-FCT	EPHEM*W(SRHIBIN)	00044	13670	00765		
-	00052				NØ-ØP		00045	12000	00000		
-	00053				EX-FCT	EPHEM*W(TAPESEARCH)	00046	13670	01421		
-	00054				JP \$		00047	61000	00047		
-	00055	NØRMAL			EX-FCT	EPHEM*W(REWINDNØ)	00050	13670	00770		
-	00056				ENT B4*L(RAAD)		00051	12410	01422		
-	00057				ENT A*L(RADIFAD)		00052	11010	01425		
-	00058				STR A*L(SETINTAD)		00053	15010	01053		
-	00061				RJP INTERPØL		00054	65000	01054		
-	00062				ENT QØ*ANES		00055	10700	00000		
-	00063				SUB A*W(TWØPIE)*APØS		00056	21630	01004		
-	00064				ADD A*W(TWØPIE)		00057	20030	01004		
-	00065				RSH AQ*270		00060	03000	00033		
-	00066				DIV W(HRAD)		00061	23030	00773		
-	00067				STR Q*W(RA2)		00062	14030	00624		
-	00070				CL Q*		00063	10000	00000		
-	00071				RSH AQ*230		00064	03000	00027		
-	00072				DIV W(MINSRAD)		00065	23030	00774		
-	00073				STR Q*W(RA4)		00066	14030	00627		
-	00074				RSH AQ*300		00067	03000	00036		
-	00075				MUL W(SRAD)		00070	22030	00772		
-	00076				LSH AQ*2*QPØS		00071	07200	00002		
-	00077				ADD A*1		00072	20000	00001		
-	00100				STR A*W(RA6)		00073	15030	00632		
-	00101				ENT B4*L(DECAD)		00074	12410	01423		
-	00102				ENT A*L(DECIFAD)		00075	11010	01426		
-	00103				STR A*L(SETINTAD)		00076	15010	01053		
-	00104				RJP INTERPØL		00077	65000	01054		
-	00105				STR A*W(GM12)		00100	15030	00712		
-	00106				ENT QØ*APØS		00101	10600	00000		
-	00107				CP A*		00102	15040	00000		
-	00110				RSH AQ*220		00103	03000	00026		
-	00111				DIV W(MINSRAD)		00104	23030	00774		
-	00112				STR Q*W(DLN2)		00105	14030	00657		
-	00113				CL Q*		00106	10000	00000		
-	00114				RSH AQ*240		00107	03000	00030		
-	00115				DIV W(SECSRAD)		00110	23030	01000		
-	00116				STR Q*W(DLN4)		00111	14030	00662		
-	00117				RSH AQ*300		00112	03000	00036		

FRACHTMAN*7/14/64

SUNTRACK

NOTES

TA STATEMENT

LI ID LABEL

CARDS

LOC

F JKB Y

00120	MUL W(SARAD)	00113	22030	01001	
00121	LSH AQ*2*QP0S	00114	07200	00002	
00122	ADD A*1	00115	20000	00001	
00123	STR A*W(DLN6)	00116	15030	00665	
00124	ENT A*W(GMT2)*ANEG	00117	11730	00712	
00125	JP \$+3	00120	61000	00123	
00126	ENT A*W(DLN2)	00121	11030	00657	
00127	STR A*CPW(DLN2)	00122	15070	00657	
00130	ENT A*W(CELTIME)	00123	11030	63133	
00131	ENT Q*0*AP0S	00124	10600	00000	
00132	CP A*	00125	15040	00000	
00133	RSH AQ*260	00126	03000	00032	
00134	DIV W(H0AY)	00127	23030	00775	
00135	STR Q*W(GMT2)	00130	14030	00712	
00136	CL Q*	00131	10000	00000	
00137	RSH AQ*230	00132	03000	00027	
00140	DIV W(MDAY)	00133	23030	00776	
00141	STR Q*W(GMT4)	00134	14030	00715	
00142	RSH AQ*300	00135	03000	00036	
00143	MUL W(SDAY)	00136	22030	00777	
00144	LSH AQ*2*QP0S	00137	07200	00002	
00145	ADD A*1	00140	20000	00001	
00146	STR A*W(GMT6)	00141	15030	00720	
00147	ENT A*W(CELTIME)*ANEG	00142	11730	63133	
00150	JP \$+3	00143	61000	00146	
00151	ENT A*W(GMT2)	00144	11030	00712	
00152	STR A*CPW(GMT2)	00145	15070	00712	
00153	ENT B*W(L(DISTAD)	00146	12410	01424	
00154	ENT A*L(DISTDIFAD)	00147	11010	01427	
00155	STR A*L(SETINTAD)	00150	15010	01053	
00156	RJP INTERP0L	00151	65000	01054	
00157	STR A*W(INITIAL18)	00152	15030	00733	
00160	ENT A*W(JULIANDAY)	00153	11030	01415	
00161	STR A*W(INITIAL3)	00154	15030	00570	
00162	ENT A*L(DAY)	00155	11010	63150	
00163	STR A*W(INITIAL12)	00156	15030	00601	
00164	RJP U(INTERC0M)	00157	65020	63426	
00165	U-TAG INITIALJD*0	00160	00560	00000	
00166	RJP U(INTERC0M)	00161	65020	63426	
00167	U-TAG RGHTASC*0	00162	00602	00000	

FRACHTMAN*7/14/64

SUNTRACK

NOTES

LOC

F JKB Y

TA STATEMENT

LI LO LABEL

CARDS

00170	RJP U(INTERCOM)			00163	65020	63426	
00171	U-TAG DLN*0			00164	00635	00000	
00172	RJP U(INTERCOM)			00165	65020	63426	
00173	U-TAG INITIALDAT*0			00166	00571	00000	
00174	RJP U(INTERCOM)			00167	65020	63426	
00175	U-TAG GMT*0			00170	00670	00000	
00176	RJP U(INTERCOM)			00171	65020	63426	
00177	U-TAG INITIALDIS*0			00172	00723	00000	
00200	RJP U(INTERCOM)			00173	65020	63426	
00201	U-TAG INITIALB00*0			00174	00734	00000	
00202	RPL Y+L*L(SUNINIT)			00175	36010	00002	
00203	JP A			00176	61070	00000	
00204	ENTRY			00177	61000	00000	
00205	RPL Y+L*L(SUNCNT)			00200	36010	00177	
00206	RJP DAYFIND			00201	65000	00274	
00207	ENT B4*L(RAAD)			00202	12410	01422	
00210	ENT A*L(RADIFAD)			00203	11010	01425	
00211	STR A*L(SETINTAD)			00204	15010	01053	
00212	RJP INTERPOL			00205	65000	01054	
00213	RSH AQ*300			00206	03000	00036	
00214	MUL W(REVS RADIAN)			00207	22030	00764	
00215	JP M00SE*QP0S			00210	60200	00212	
00216	ADD A*1			00211	20000	00001	
00217	STR A*W(RA)			00212	15030	63002	
00220	ENT Q*W(NUMDERIV)			00213	10030	01045	
00221	MUL W(RDRSEC)			00214	22030	01003	
00222	ENT B5*4			00215	12500	00004	
00223	RJP R0UND0FF			00216	65000	01403	
00224	STR A*W(RAD0T)			00217	15030	63007	
00225	ENT B4*L(DECAD)			00220	12410	01423	
00226	ENT A*L(DECUIFAD)			00221	11010	01426	
00227	STR A*L(SETINTAD)			00222	15010	01053	
00230	RJP INTERPOL			00223	65000	01054	
00231	RSH AQ*300			00224	03000	00036	
00232	MUL W(REVS RADIAN)			00225	22030	00764	
00233	JP NEGDEC*ANEG			00226	60700	00505	
00234	JP BEAVER*QP0S			00227	60200	00231	
00235	ADD A*1			00230	20000	00001	
00236	STR A*W(DEC)			00231	15030	63003	
00237	ENT Q*W(NUMDERIV)			00232	10030	01045	

037 RADS/SEC

FRACHTMAN#7/14/64

SUNTRACK

CARDS	LI	ID	LABEL	TA	STATEMENT	LDC	F	JKS	Y	NOTES
	00240			MUL	W(RDRSEC)	00233	22030	01003		
	00241			ENT	B5*4	00234	12500	00004		
	00242			RJP	R0UND0FF	00235	65000	01403		
	00243			STR	A*W(DECD0T)	00236	15030	63010		B37 RADS/SEC
	00244			ENT	B4*L(DISTAD)	00237	12410	01424		
	00245			ENT	A*L(DISTDIFAD)	00240	11010	01427		
	00246			STR	A*L(SETINTAD)	00241	15010	01053		
	00247			RJP	INTERP0L	00242	65000	01054		
	00250			RSH	AQ*4*QP0S	00243	03200	00004		
	00251			ADD	A*1	00244	20000	00001		
	00252			SUB	A*W(SUNRAD)	00245	21030	01005		
	00253			CP	A*	00246	15040	00000		
	00254			STR	A*W(RADIUS)	00247	15030	63006		
	00255			ENT	Q*W(NUMDERIV)	00250	10030	01045		
	00256			MUL	W(AUDNMSEC)	00251	22030	01002		
	00257			ENT	B5*7	00252	12500	00007		SUN
	00260			RJP	LEFRND0FF	00253	65000	01373		
	00261			STR	A*W(RADIUS00T)	00254	15030	63011		B24 NM/SEC
	00262	SEAP0RT		EXIT		00255	61010	00177		
	00263	FLATNEG		CP	A*	00256	15040	00000		
	00264			SUB	A*W(HALFDAY)*AP0S	00257	21630	00763		
	00265			JP	LESS0NE	00260	61000	00272		
	00266			RSH	AQ*30D	00261	03000	00036		
	00267			DIV	W(HALFUAY)	00262	23030	00763		
	00270			LSH	AQ*30D	00263	07000	00036		
	00271			SUB	A*1	00264	21000	00001		
	00272			JP	TW0LESS*AZER0	00265	60400	00270		
	00273			JP	TW0LESS*ANEG	00266	60700	00270		
	00274			ENT	A*-3*SKIP	00267	11140	77774		
	00275	TW0LESS		ENT	A*-2	00270	11040	77775		
	00276			JP	ST0RE	00271	61000	00334		
	00277	LESS0NE		ENT	A*-1	00272	11040	77776		
	00300			JP	ST0RE	00273	61000	00334		
	00301	DAYFIND		ENTRY		00274	61000	00000		
	00302			ENT	A*W(CELTIME)	00275	11030	63133		
	00303			ADD	A*W(DELTATEE)*AP0S	00276	20630	63316		
	00304			JP	NEGTIME	00277	61000	00311		
	00305			LSH	A*1*AP0S	00300	06600	00001		
	00306			SUB	A*W(KEY)*SKIP	00301	21130	01017		
	00307			STR	A*W(P)*SKIP	00302	15130	01026		

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SUNTRACK

CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
•	00310			STR	A*(P)*SKIP	00303	15130	01026		
•	00311			ENT	A*(P)*SKIP	00304	11100	00000		
•	00312			ENT	A*1	00305	11000	00001		
•	00313			JP	TIMESLIDE	00306	61000	00317		
•	00314	DAYINDEX		Ø		00307	00000	00000		
•	00315	DAYINCRMT		Ø		00310	00000	00000		
•	00316	NEGTIME		LSH	A*1*AP0S	00311	06600	00001		
•	00317			SUB	A*(KEY)*SKIP	00312	21130	01017		
•	00320			STR	A*(P)*SKIP	00313	15130	01026		
•	00321			STR	A*(P)*SKIP	00314	15130	01026		
•	00322			ENT	A*-2*SKIP	00315	11140	77775		
•	00323			ENT	A*-1	00316	11040	77776		
•	00324			STR	A*(DAYINDEX)	00317	15030	00307		
•	00325			ENT	A*(CELTIME)*AP0S	00320	11630	63133		
•	00326			JP	FLATNEG	00321	61000	00256		
•	00327			SUB	A*(HALFDAY)*AP0S	00322	21630	00763		
•	00330			JP	LESS0NE	00323	61000	00272		300
•	00331			RSH	AQ*	00324	03000	00000		
•	00332			DIV	W(HALFDAY)	00325	23030	00763		
•	00333			LSH	AQ*300	00326	07000	00036		
•	00334			SUB	A*1	00327	21000	00001		
•	00335			JP	CER0*AZER0	00330	60400	00333		
•	00336			JP	CER0*ANEG	00331	60700	00333		
•	00337			ENT	A*1*SKIP	00332	11100	00001		
•	00340	CER0		ENT	A*0	00333	11000	00000		
•	00341	STORE		STR	A*(DAYINCRMT)	00334	15030	00310		
•	00342			ADD	A*(WHOLEYEAR)	00335	20030	01414		
•	00343			ADD	A*24373000	00336	20030	03172		JD DEC 31 1960 GNVCH N00N
•	00344			ADD	A*L(DAY)	00337	20010	63150		
•	00345			STR	A*(JULIANDAY)	00340	15030	01415		
•	00346			ADD	A*(DAYINDEX)	00341	20030	00307		
•	00347			SUB	A*24381510	00342	21030	03173		JD MAY 1 1963 GNVCH N00N
•	00350			SUB	A*(DAYINCRMT)	00343	21030	00310		
•	00351			RSH	AQ*300	00344	03000	00036		
•	00352			DIV	320	00345	23000	00040		
•	00353			STR	Q*(TAPEBL0CK)	00346	14030	01417		
•	00354			STR	Q*(SL0TBL0CK)	00347	15030	01420		
•	00355			ENT	Q*(SL0TBL0CK)	00350	10030	01420		
•	00356			MUL	11	00351	22000	00011		

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SUNTRACK

NOTES

LOC

F JKB Y

TA STATEMENT

LI ID LABEL

CARDS

00357	ADD	Q*AEPPHEM+2J00	00352	26000	02073	
00360	STR	Q*L(RAAD)	00353	14010	01422	
00361	ADD	Q*1	00354	26000	00001	
00362	STR	Q*L(RADIFAD)	00355	14010	01425	
00363	ADD	Q*1	00356	26000	00001	
00364	STR	Q*L(DECAD)	00357	14010	01423	
00365	ADD	Q*1	00360	26000	00001	
00366	STR	Q*L(DECIFAD)	00361	14010	01426	
00367	ADD	Q*1	00362	26000	00001	
00370	STR	Q*L(DISTAD)	00363	14010	01424	
00371	ADD	Q*1	00364	26000	00001	
00372	STR	Q*L(DISTIFAD)	00366	14010	01427	
00373	EXIT		00367	61000	00274	
00374	ENTRY		00370	61000	00000	
00375	STR	EPHEM*W(TAPSTAT)	00371	17670	00502	
00376	ENT	A*U(TAPSTAT)	00372	11020	00502	
00377	RSH	A*11D	00373	02000	00013	
00400	STR	A*W(TAPSTAT+1)	00374	15030	00503	
00401	RPL	Y+1*L(STATUSCK)	00375	36010	00367	
00402	ENT	B3*L(TAPSTAT+1)	00376	12310	00503	
00403	RIL		00377	60000	00000	
00404	JP	STATACT+B3	00377	61003	00400	
00405	JP	BUST	00400	61000	00454	
00406	JP	BUST	00401	61000	00454	
00407	JP	BUST	00402	61000	00454	
00410	JP	BUST	00403	61000	00454	
00411	JP	BUST	00404	61000	00454	
00412	JP	BUST	00405	61000	00454	
00413	JP	BUST	00406	61000	00454	
00414	JP	BUST	00407	61000	00454	
00415	EXIT		00410	61010	00367	
00416	JP	BUST	00411	61000	00367	
00417	JP	BUST	00412	61000	00454	
00420	JP	ENDFILE	00413	61000	00450	
00421	JP	CANTFIND	00414	61000	00420	
00422	JP	BUST	00415	61000	00454	
00423	JP	BUST	00416	61000	00454	
00424	JP	BUST	00417	61000	00454	
00425	EX-FCT	EPHEM*W(REWINDN0)	00417	61000	00454	
00426	ENT	B4*L(MONTHPRINT)	00420	13670	00770	
			00421	12410	00746	

4 SEQ ERR SYNC 20
 5 REWINDING 24
 6 CHAR COUNT 30
 7 ILLEGAL 34
 10 40 NORMAL
 11 REPEAT 44
 12 SEQ ERR COUNT 50
 13 EOF 54
 14 EOI 60
 15 NONSUCH
 16 ABN F C 70
 17 INTERLOCK 74

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SUNTRACK

CARDS	LI	ID	LABEL	TA	STATEMENT	LDC	F	JKB	Y	NOTES
•	00427			ENT	A#W(YEARPRINT+B4)	00422	11034	01006		
•	00430			STR	A#W(N0DATA2)	00423	15030	00551		
•	00431			ENT	B4#L(YEARM0NTH)	00424	12410	63147		
•	00432			ENT	A#W(M0NTHPRINT+B4)	00425	11034	00746		
•	00433			RPL	A+Y#W(N0DATA2)	00426	24030	00551		
•	00434			CL	A#	00427	11000	00000		
•	00435			ENT	Q#L(BARRIER)	00430	10010	00451		
•	00436			DIV	I2	00431	23000	00012		
•	00437			ADD	A#60	00432	20000	00060		
•	00440			STR	A#U(IMPERIAL)	00433	15020	01416		
•	00441			CL	A#	00434	11000	00000		
•	00442			DIV	I2	00435	23000	00012		
•	00443			JP	ALBERT#AZER0	00436	60400	00440		
•	00444			AUD	A#60	00437	20000	00060		
•	00445	ALBERT		LSH	A#6	00440	06000	00006		
•	00446			ADD	A#U(IMPERIAL)	00441	20020	01416		
•	00447			LSH	A#6	00442	06000	00006		
•	00450			ADD	A#3105000005	00443	20030	03174		
•	00451			STR	A#W(N0DATA3)	00444	15030	00555		
•	00452			RJP	U(INTERCOM)	00445	65020	63426		
•	00453			U-TAG	N0DATA#0	00446	00543	00000		
•	00454			JP	L(SUNINIT)	00447	61010	00002		
•	00455	ENDFILE		RPL	Y+1#L(IMPERIAL)	00450	36010	01416		
•	00456	BARRIER		SUB	A#11	00451	21000	00011		SUN
•	00457			JP	CAVIFIND#AZER0	00452	60400	00420		
•	00460			JP	TRYAGAIN	00453	61000	00034		
•	00461	BUST		EX-FCT	EPHEM#W(REWINDN0)	00454	13670	00770		
•	00462			ENT	A#L(TAPSTAT+1)	00455	11010	00503		
•	00463			RSH	A#1	00456	02000	00001		
•	00464			ADD	A#60	00457	20000	00060		
•	00465			LSH	A#6	00460	06000	00006		
•	00466			STR	A#L(TAPSTAT+2)	00461	15010	00504		
•	00467			ENT	A#L(TAPSTAT+1)	00462	11010	00503		
•	00470			SEL	CL#X77776	00463	52040	77776		
•	00471			LSH	A#2	00464	06000	00002		
•	00472			ADD	A#60	00465	20000	00060		
•	00473			AUD	A#L(TAPSTAT+2)	00466	20010	00504		
•	00474			STR	A#L(TAPEBUST1+3)	00467	15010	00503		
•	00475			RJP	U(INTERCOM)	00470	65020	63426		
•	00476			U-TAG	TAPEBUST#0	00471	00473	00000		

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CARDS	LI	ID LABEL	TA STATEMENT	LOC	F	JK	Y	NOTES
•	00477		JP L(SUNINIT)	00472	61010	00002		
•	00500	TAPEBUST	FD A*	00473	00050	00505		
•	00511		-0 TAPEBUST1	00474	77777	00475		
•	00502	TAPEBUST1	FD 0*IIIC	00475	16161	01005		
•	00503		FU 0*STATU	00476	30310	03132		
•	00504		FD 2*S SI	00477	30050	03061		
•	00505		-0	00500	00050	00505		
•	00506		+0	00501	77777	77777		
•	00507		+0	00502	00000	00000		
•	00510		+0	00503	00000	00000		
•	00511	NEGDEC	JP BEAVER=QNEG	00504	00000	00000		
•	00512		SUB A*	00505	60300	00231		
•	00513		JP BEAVER	00506	21000	00001		
•	00514	N0TIN	ADD A*	00507	61000	00231		
•	00515		SUB A*W(SL0TBL0CK)	00510	00000	00001		
•	00516		JP BL0CKAY*AP0S	00511	21030	01420		
•	00517	BL0CKEE	IN EPHEM*W(EPHEMB)	00512	00000	00530		
•	00520		N0-JP	00513	73670	00541		
•	00521		EX-FCT EPHEM*W(SRHIBIN)	00514	12000	00000		
•	00522		N0-JP	00515	13670	00765		
•	00523		EX-FCT EPHEM*W(TAPESEARCH)	00516	12000	00000		
•	00524		JP \$	00517	13670	01421		
•	00525		IN EPHEM*W(EPHEMC)	00520	01000	00520		
•	00526	PATCH	ENT A*40	00521	73670	00542		
•	00527		EX-FCT EPHEM*W(SRHIBIN)	00522	11000	00040		
•	00530		RPL A+Y*W(TAPESEARCH)	00523	13670	00765		
•	00531		EX-FCT EPHEM*W(TAPESEARCH)	00524	24030	01421		
•	00532		JP \$	00525	13670	01421		
•	00533		JP N0RMAL	00526	61000	00520		
•	00534	BL0CKAY	IN EPHEM*W(EPHEMA)	00527	01000	00050		
•	00535		ENT A*-40	00531	73670	00540		
•	00536		EX-FCT EPHEM*W(SRHIBIN)	00532	11040	77737		
•	00537		RPL A+Y*W(TAPESEARCH)	00533	13670	00765		
•	00540		EX-FCT EPHEM*W(TAPESEARCH)	00534	24030	01421		
•	00541		JP \$	00535	13670	01421		
•	00542		IN EPHEM*W(EPHEMB)	00530	73670	00541		
•	00543		JP PATCH	00537	61000	00522		
•	00544	EPHEMA	U-TAG EPHEM*2070*AEPHEM	00540	02070	01431		
•	00545	EPHEMB	U-TAG EPHEM*5750*AEPHEM*2880	00541	02530	02071		

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SUNTRACK

CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00546		EPHEMC		U-TAG	00542				
.	00547		N0DATA		FD 0*A	00543			02531	
.	00550				-0 N0DATA1	00544			00505	
.	00551		N0DATA1		FD 0*SUN E	00545			00545	
.	00552				FD 0*PHEME	00546			30322	
.	00553				FD 0*FIS F	00547			00512	
.	00554				FD 0*0R	00548			25151	
.	00555		N0DATA2		FD 0*63/63	00550			27163	
.	00556				FD 0* N0T	00551			00513	
.	00557				FD 0*AM0NG	00552			24270	
.	00560				FD 0* FIRS	00553			00505	
.	00561		N0DATA3		FD 0*1	00554			66637	
.	00562				FD 0*FILES	00555			05232	
.	00563				-0	00556			43105	
.	00564		INITIALJD		FD 0*A	00557			06222	
.	00565				U-TAG INITIAL2*INITIAL1	00560			05131	
.	00566		INITIAL1		FD 0*JULIA	00561			62730	
.	00567				FD 2*N DAY	00562			31050	
.	00570				-0	00563			13162	
.	00571		INITIAL2		FD 0*D	00564			77777	
.	00572				-0 INITIAL3	00565			06050	
.	00573		INITIAL3		FD 0	00566			50505	
.	00574		INITIALDAT		FD 0*A	00567			11050	
.	00575				U-TAG INITIAL11*INITIAL10	00570			77777	
.	00576		INITIAL10		FD 3*DAY 0F YEAR	00571			00570	
.	00577				-0	00572			00571	
.	00600		INITIAL11		FD 0*D	00573			00577	
.	00601				-0 INITIAL12	00574			11063	
.	00602		INITIAL12		FD 0	00575			13053	
.	00603		RGHTASC		FD 0*A	00576			61206	
.	00604				FD RAI	00577			27050	
.	00605				FD 0*D	00578			77777	
.	00606				FD RA2	00579			11050	
.	00607				FD 0*A	00580			50505	
.	00610				FD RA3	00581			00600	
.	00611				FD 0*D	00582			06050	
.	00612				FD 0	00583			00600	

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SUNTRACK

CARDS	LI	ID	LABEL	TA	STATEMENT	LUC	F	JKB	Y	NOTES
.	00613			FD	0*A	00612	06050	50505		
.	00614			0	RA5	00613	00000	00630		
.	00615			FD	0*X2B23	00614	35620	76263		
.	00616			0	RA6	00615	00000	00632		
.	00617			FD	0*A	00616	06050	50505		
.	00620			-0	RA7	00617	77777	00633		
.	00621	RA1		FD	3*RIGHT ASC	00620	27161	41531		
						00621	05063	01005		
						00622	05050	50505		
						00623	77777	77777		
.	00622			-0		00624	00000	00000		
.	00623	RA2		0		00625	00000	01505		
.	00624	RA3		1505		00626	77777	77777		
.	00625			-0		00627	00000	00000		
.	00626	RA4		0		00630	00000	02205		
.	00627	RA5		2205		00631	77777	77777		
.	00630			-0		00632	00000	00000		
.	00631	RA6		0		00633	00000	00030		
.	00632	RA7		30		00634	77777	77777		
.	00633			-0		00635	06050	50505		
.	00634	DLN		FD	0*A	00636	00000	00653		
.	00635			0	DLN1	00637	11050	50505		
.	00636			FD	0*D	00640	00000	00657		
.	00637			0	DLN2	00641	06050	50505		
.	00640			FD	0*A	00642	00000	00660		
.	00641			0	DLN3	00643	11050	50505		
.	00642			FD	0*D	00644	00000	00662		
.	00643			0	DLN4	00645	06050	50505		
.	00644			FD	0*A	00646	00000	00663		
.	00645			0	DLN5	00647	35620	76263		
.	00646			FD	0*X2B23	00650	00000	00665		
.	00647			0	DLN6	00651	06050	50505		
.	00650			FD	0*A	00652	77777	00666		
.	00651			-0	DLN7	00653	11121	02116		
.	00652	DLN1		FD	3*DECLINATION	00654	23063	11624		
						00655	23050	50505		
						00656	77777	77777		
.	00653			-0		00657	00000	00000		
.	00654	DLN2		0		00660	00000	01105		
.	00655	DLN3		1105		00661	77777	77777		
.	00656			-0						

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SUNTRACK

NOTES

TA STATEMENT

LI ID LABEL

CARDS

F JKB Y

LUC

00657	DLN4	0	00662	00000	00000	
00660	DLN5	7205	00663	00000	07205	
00661		-0	00664	77777	77777	
00662	DLN6	0	00665	00000	00000	
00663	DLN7	52	00666	00000	00052	
00664		-0	00667	77777	77777	
00665	GMT	0*A	00670	06050	50505	
00666		0	00671	00000	00706	
00667		FD 0*D	00672	11050	50505	
00670		0	00673	00000	00712	
00671		FD 0*A	00674	06050	50505	
00672		0	00675	00000	00713	
00673		FD 0*D	00676	11050	50505	
00674		0	00677	00000	00715	
00675		FD 0*A	00700	06050	50505	
00676		0	00701	00000	00716	
00677		FD 0*X2823	00702	35620	76263	
00700		0	00703	00000	00720	
00701		FD 0*A	00704	06050	50505	
00702		-0	00705	77777	00721	
00703	GMT1	FD 3*UNIVERSAL TIME	00706	32231	63312	
			00707	27300	62105	
			00710	31162	21205	
			00711	77777	77777	
			00712	00000	00000	
			00713	00000	01505	
			00714	77777	77777	
			00715	00000	00000	
			00716	00000	02205	
			00717	77777	77777	
			00720	00000	00000	
			00721	00000	00030	
			00722	77777	77777	
			00723	06050	50505	
			00724	00731	00725	
			00725	11163	03106	
			00726	23101	20505	
			00727	06053	20505	
			00730	77777	77777	
			00731	35700	76270	

INITIAL17*INITIAL16

0*A

FD

INITIALDIS

00716

U-TAG

FD

INITIAL16

00717

0*DISTA

FD

00720

0*NCE

FD

00721

0*A U

FD

00722

0*X8828

FD

INITIAL17

00723

SPURT OUTPUT NO. 210

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SUNTRACK

TA STATEMENT

LI ID LABEL

NOTES

F JKB Y

LOC

CARDS

00725	INITIAL18	-0	INITIAL18	00732	77777	00133	
00726	INITIAL18	0		00733	00000	00000	
00727	INITIAL000	FD	0*A	00734	06050	00505	
00730	INITIAL19	U-TAG	INITIAL20*INITIAL19	00735	00742	00736	
00731	INITIAL19	FD	3*08JECT	00736	24071	71210	
				00737	31050	00505	
				00740	05050	00505	
00732	INITIAL20	-0		00741	77777	77777	
00733	INITIAL20	FD	0*A	00742	06050	00505	
00734	INITIAL21	-0	INITIAL21	00743	77777	00744	
00735	INITIAL21	3032230000		00744	30322	30000	FD 0 SUN
00736	MONTHPRINT	-0		00745	77777	77777	
00740		0		00746	00000	00000	
00741		0061000000		00747	00610	00000	
00742		0062000000		00750	00620	00000	
00743		0063000000		00751	00630	00000	
00743		0064000000		00752	00640	00000	
00744		0065000000		00753	00650	00000	
00745		0066000000		00754	00660	00000	
00746		0067000000		00755	00670	00000	
00747		0070000000		00756	00700	00000	
00750		0071000000		00757	00710	00000	
00751		6160000000		00760	61600	00000	
00752		6161000000		00761	61610	00000	
00753		6162000000		00762	61620	00000	
00754	HALFDAY	1000000000		00763	10000	00000	DEC
00755	REVSADIAN	2427630154		00764	24276	30154	0.63661977829
00756	SRHIBIN	5600000000		00765	56000	00002	
00757	IGNORE	6000000000		00766	60000	00000	
00760	INTERUPT	RJP STATUSCK		00767	65000	00367	
00761	REWINDN0	2010000002		00770	20100	00002	1 B N0 INT
00762	IDEN	0001200000		00771	00012	00000	SUN
00763	SRAD	3266677126		00772	32666	77126	DEC
							13750.987815
00764	HRAD	1030124435		00773	10301	24435	200/PI
							DEC
00765	MINSRAD	2167643241		00774	21676	43241	/12
							DEC
00766	HDAY	1252525250		00775	12525	25250	8PI/120
							DEC

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PI
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SPURT OUTPUT NO. 210

FRACHTMAN*7/14/64

SUNTRACK

CARDS	LI	ID LABEL	TA STATEMENT	LOC	F	JKB Y	NOTES	
.	007767	MDAY	2660266026	007776	26602	66026	24 032 DEC	71111111829 2E
.	007770	SDAY	2506000000	007777	25060	00000	10/1440 DEC	86400.000812
.	007771	SECSRAD	2304045527	010000	23040	45527	DEC	59573905829 2E
.	007772	SARAD	3113343172	010001	31133	43172	13PI/43200 DEC	206264.01811 64
.	007773	AUDNMSEC	3515643656	010002	35156	43656	800/PI DEC	934.91819
.	007774	RDRSEC	3021344241	010003	30213	44241	DEC	75851852829 2E1
.	007775	TW0PIE	3110375523	010004	31103	75523	6/86400 DEC	6.2831853826
.	007776	SUNRAD	0000230432	010005	00002	30432	DEC	0046555824 SUN 696
.	007777	YEARPRINT	0000746661	010006	00007	46661		
.	010000		0000746662	010007	00007	46662		
.	010001		0000746663	010010	00007	46663		
.	010002		0000746664	010011	00007	46664		
.	010003		0000746665	010012	00007	46665		
.	010004		0000746666	010013	00007	46666		
.	010005		0000746667	010014	00007	46667		
.	010006		0000746670	010015	00007	46670		
.	010007		0000746671	010016	00007	46671		
.	010010	KEY	4000000000	010017	40000	00000		
.	010011	FIRSTDIFF	0	010020	00000	00000		
.	010012	BETA	0	010021	00000	00000		
.	010013	GAMMA	0	010022	00000	00000		
.	010014	DELTA	0	010023	00000	00000		
.	010015	EPSILON	0	010024	00000	00000		
.	010016	FUNCTION	0	010025	00000	00000		
.	010017	P	0	010026	00000	00000		
.	010020	HALF	2000000000	010027	20000	00000		
.	010021	DMIN3	0	010030	00000	00000		
.	010022	DMIN2CPL3	0	010031	00000	00000		
.	010023	EP2BM2DMA	0	010032	00000	00000		
.	010024	BESSEL	0	010033	00000	00000		
.	010025		0	010034	00000	00000		

CARDS	LI	ID	LABEL	TA	STATEMENT	F	JKB	Y	LUC	NOTES
.	01026					00000	00000	00000	01035	
.	01027					00000	00000	00000	01036	
.	01030					00000	00000	00000	01037	
.	01031		PSQMP			00000	00000	00000	01040	
.	01032		PSQMP6			00000	00000	00000	01041	
.	01033		THIRD		1252525252	00000	00000	00000	01042	
.	01034		SIXTH		0525252525	00000	00000	00000	01043	
.	01035		KENNEDY			00000	00000	00000	01044	
.	01036		NUMBERIV			00000	00000	00000	01045	
.	01037		BESSEL			00000	00000	00000	01046	
.	01040					00000	00000	00000	01047	
.	01041					00000	00000	00000	01050	
.	01042					00000	00000	00000	01051	
.	01043					00000	00000	00000	01052	
.	01044					00000	00000	00000	01053	
.	01045		SETINTAD			00000	00000	00000	01054	
.	01046		INTERPOL			00000	00000	00000	01055	
.	01047				ENTRY Q*-11	00000	00000	00000	01056	
.	01050				RPL Y+Q*L(SETINTAD)	00000	00000	00000	01057	
.	01051				ENT B3*L(SETINTAD)	00000	00000	00000	01060	
.	01052				CL Q*	00000	00000	00000	01061	
.	01053				ENT A*(0+B3)	00000	00000	00000	01062	
.	01054				STR A*(BETA)	00000	00000	00000	01063	
.	01055				ENT B3*11+B3	00000	00000	00000	01064	
.	01056				ENT A*(0+B3)	00000	00000	00000	01065	
.	01057				STR A*(GAMMA)	00000	00000	00000	01066	
.	01060				ENT B3*11+B3	00000	00000	00000	01067	
.	01061				ENT A*(0+B3)	00000	00000	00000	01070	
.	01062				STR A*(DELTA)	00000	00000	00000	01071	
.	01063				ENT A*(DELTA)	00000	00000	00000	01072	
.	01064				SUB A*(BETA)	00000	00000	00000	01073	
.	01065				STR A*(DMINB)	00000	00000	00000	01074	
.	01066				ADD A*(DMINB)	00000	00000	00000	01075	
.	01067				STR A*(BESSEL)	00000	00000	00000	01076	
.	01070				ENT A*(DELTA)	00000	00000	00000	01077	
.	01071				ADD A*(BETA)	00000	00000	00000	01100	
.	01072				SUB A*(GAMMA)	00000	00000	00000	01101	
.	01073				SUB A*(GAMMA)	00000	00000	00000	01102	
.	01074				STR A*(DMIN2CPLB)	00000	00000	00000	01103	
.	01075				JP OIFF4ZER0*QP0S	00000	00000	00000	01104	
.					ENT A*(EPSILON)	00000	00000	00000		

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SUNTRACK

CARDS	LI	ID	LABEL	TA	STATEMENT	LUC	F	JKB	Y	NOTES
•	01076			SUB	A*(FIRSTDIFF)	01105	21030	01020		
•	01077			SUB	A*(BESSEL)	01106	21030	01033		
•	01100			STR	A*(EP2BM20MA)	01107	15030	01032		
•	01101	PARTIAL		ENT	Q*(P)	01110	10030	01026		
•	01102			MUL	W(GAMMA)	01111	22030	01022		
•	01103			LSH	AQ*1	01112	07000	00001		
•	01104			STR	A*(BESSEL+1)	01113	15030	01034		
•	01105			STR	A*(BESSEL)*AP0S	01114	15630	01033		
•	01106			JP	NEGBESS1	01115	61000	01357		
•	01107			LSH	AQ*290	01116	07000	00035		
•	01110			SEL	CL*(KEY)	01117	52030	01017		
•	01111			STR	A*(FBESSEL)	01120	15030	01046		
•	01112			STR	A*(FBESSEL+1)	01121	15030	01047		
•	01113	ST0R1		ENT	Q*(P)	01122	10030	01026		
•	01114			MUL	W(P)	01123	22030	01026		
•	01115			ENT	B5*1	01124	12500	00001		
•	01116			RJP	LEFRND0FF	01125	65000	01373		
•	01117			SUB	A*(P)	01126	21030	01026		
•	01120			STR	A*(PSQMP)	01127	15030	01040		
•	01121			RSH	AQ*300	01130	03000	00036		
•	01122			MUL	W(DMINB)	01131	22030	01030		
•	01123			RSH	AQ*1	01132	03000	00001		
•	01124			STR	A*(BESSEL+2)*AP0S	01133	15630	01035		
•	01125			JP	NEGBESS2	01134	61000	01362		
•	01126			LSH	AQ*290	01135	07000	00035		
•	01127			SEL	CL*(KEY)	01136	52030	01017		
•	01130	ST0R2		STR	A*(FBESSEL+2)	01137	15030	01050		
•	01131			ENT	A*(PSQMP)	01140	11030	01040		
•	01132			RSH	AQ*300	01141	03000	00036		
•	01133			DIV	6*AZER0	01142	23400	00006		
•	01134			JP	REMAINDER	01143	61000	01257		
•	01135	LINC0LN		STR	Q*(PSQMP6)	01144	14030	01041		
•	01136			ENT	Q*(P)	01145	10030	01026		
•	01137			SUB	Q*(HALF)	01146	27030	01027		
•	01140			MUL	W(PSQMP6)	01147	22030	01041		
•	01141			RJP	LEFRND0FF	01150	65000	01373		
•	01142			RSH	AQ*300	01151	03000	00036		
•	01143			MUL	W(DMIN2CPLB)	01152	22030	01031		
•	01144			LSH	AQ*1	01153	07000	00001		
•	01145			STR	A*(BESSEL+3)*AP0S	01154	15630	01036		

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SUNTRACK

CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
•	01146			JP	NEGBESS3	01155	61000	01365		
•	01147			LSH	AQ*29D	01156	07000	00035		
•	01150			SEL	CL*W(KEY)	01157	52030	01017		
•	01151	ST0R3		STR	A*W(FBESSEL+3)	01160	15030	01051		
•	01152			ENT	A*W(EP2BM2DMA)*ANOT	01161	11530	01032		
•	01153			JP	NØFØURTH	01162	61000	01252		
•	01154			ENT	Q*W(PSQMP6)	01163	10030	01041		
•	01155			SUB	Q*W(THIRD)	01164	27030	01042		
•	01156			MUL	W(PSQMP)	01165	22030	01040		
•	01157			RJP	LEFRNDØFF	01166	65000	01373		
•	01160			RSH	AQ*30D	01167	03000	00036		
•	01161			MUL	W(EP2BM2DMA)	01170	22030	01032		
•	01162			RSH	AQ*2	01171	03000	00002		
•	01163			STR	A*W(BESSEL+4)*APØS	01172	15630	01037		
•	01164			JP	NEGBESS4	01173	61000	01370		
•	01165			LSH	AQ*29D	01174	07000	00035		
•	01166			SEL	CL*W(KEY)	01175	52030	01017		
•	01167	STØR4		STR	A*W(FBESSEL+4)	01176	15030	01052		
•	01170			ENT	A*W(FBESSEL)	01177	11030	01046		
•	01171			SEL	CP*W(FBESSEL+2)	01200	51030	01050		
•	01172			JP	FLØTEST1*APØS	01201	60600	01271		
•	01173	NØFLØ1		ENT	Q*W(BESSEL+2)	01202	10030	01035		
•	01174	FIX1		RPL	Y+Q*W(BESSEL)	01203	34030	01033		
•	01175			ENT	A*W(FBESSEL+2)	01204	11030	01050		
•	01176			RPL	A+Y*W(FBESSEL)	01205	24030	01046		
•	01177			SEL	CP*W(FBESSEL+3)	01206	51030	01051		
•	01200			JP	FLØTEST2*APØS	01207	60600	01313		
•	01201	NØFLØ2		ENT	Q*W(BESSEL+3)	01210	10030	01036		
•	01202	FIX2		RPL	Y+Q*W(BESSEL)	01211	34030	01033		
•	01203			ENT	A*W(FBESSEL+3)	01212	11030	01051		
•	01204			RPL	A+Y*W(FBESSEL)	01213	24030	01046		
•	01205			SEL	CP*W(FBESSEL+4)	01214	51030	01052		
•	01206			JP	FLØTEST3*APØS	01215	60600	01335		
•	01207	NØFLØ3		ENT	Q*W(BESSEL+4)	01216	10030	01037		
•	01210	FIX3		RPL	Y+Q*W(BESSEL)	01217	34030	01033		
•	01211			ENT	A*W(FBESSEL+4)	01220	11030	01052		
•	01212			RPL	A+Y*W(FBESSEL)	01221	24030	01046		
•	01213			ENT	Q*W(P)	01222	10030	01026		
•	01214			SUB	Q*W(HALF)	01223	27030	01027		
•	01215			MUL	W(DMINB)	01224	22030	01030		

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SUNTRACK

CARDS	LI	ID LABEL	TA STATEMENT	LOC	F	JKB Y	NOTES
•	01216		CL B5*	01225	12500	00000	
•	01217		RJP LEFRND0FF	01226	65000	01373	
•	01220		STR A*W(KENNEDY)	01227	15030	01044	
•	01221		ENT Q*W(PSQMP)	01230	10030	01040	
•	01222		ADD Q*W(SIXTH)	01231	26030	01043	
•	01223		MUL W(DMIN2CPLB)	01232	22030	01031	
•	01224		RJP LEFRND0FF	01233	65000	01373	
•	01225		ADD A*W(KENNEDY)	01234	20030	01044	
•	01226		ADD A*W(GAMMA)	01235	20030	01022	
•	01227		STR A*W(NUMDERIV)	01236	15030	01045	
•	01230		ENT A*W(FBESSEL)*AP0S	01237	11630	01046	
•	01231		JP MINUS	01240	61000	01246	
•	01232		LSH A*1*ANEG	01241	06700	00001	
•	01233		ENT A*W(BESSEL)*SKIP	01242	11130	01033	
•	01234		RPL Y+1*W(BESSEL)	01243	36030	01033	
•	01235	SUM	ADD A*W(0+B4)	01244	20034	00000	
•	01236		EXIT	01245	61010	01054	
•	01237	MINUS	LSH A*1*AP0S	01246	06600	00001	
•	01240		ENT A*W(BESSEL)*SKIP	01247	11130	01033	
•	01241		RPL Y-1*W(BESSEL)	01250	37030	01033	
•	01242		JP SUM	01251	61000	01244	
•	01243	N0F0URTH	CL A*	01252	11000	00000	
•	01244		STR A*W(BESSEL+4)	01253	15030	01037	
•	01245		JP ST0R4	01254	61000	01176	
•	01246	DIFF4ZER0	STR Q*W(EP2BM20MA)	01255	14030	01032	
•	01247		JP PARTIAL	01256	61000	01110	
•	01250	REMAINDER	JP CIVIL*QP0S	01257	60200	01265	
•	01251		STR A*1	01260	15040	00000	
•	01252		SUB A*3*AP0S	01261	21600	00003	
•	01253		JP LINC0LN	01262	61000	01144	
•	01254		SUB Q#1	01263	27000	00001	
•	01255		JP LINC0LN	01264	61000	01144	
•	01256	CIVIL	SUB A*3*AP0S	01265	21600	00003	
•	01257		JP LINC0LN	01266	61000	01144	
•	01260		ADD Q#1	01267	26000	00001	
•	01261		JP LINC0LN	01270	61000	01144	
•	01262	FL0TEST1	ENT A*W(FBESSEL)*ANEG	01271	11730	01046	
•	01263		ADD A*W(FBESSEL+2)*SKIP	01272	20130	01050	
•	01264		JP B0THNEG1	01273	61000	01303	
•	01265		JP N0FL01*AP0S	01274	60600	01202	

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SUNTRACK

CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
•	J1266			SEL	CL*W(KEY)	01275	52030	01017		
•	01267			STR	A*W(FBESSEL)	01276	15030	01046		
•	01270			ENT	Q*W(BESSEL+2)	01277	10030	01035		
•	01271			ADD	Q*1	01301	26000	00001		
•	01272			RPL	Y+Q*W(BESSEL)	01301	34030	01033		
•	01273			JP	FIX1+3	01302	61000	01206		
•	01274	B0THNEG1		ADD	A*W(FBESSEL+2)	01303	20030	01050		
•	01275			JP	N0FL01*ANEG	01304	60700	01202		
•	01276			SEL	SET*W(KEY)	01305	50030	01017		
•	01277			STR	A*W(FBESSEL)	01306	15030	01046		
•	01300			ENT	Q*W(BESSEL+2)	01307	10030	01035		
•	01301			SUB	Q*1	01310	27000	00001		
•	01302			RPL	Y+Q*W(BESSEL)	01311	34030	01033		
•	01303			JP	FIX1+3	01312	61000	01206		
•	01304	FL0TEST2		ENT	A*W(FBESSEL)*ANEG	01313	11730	01046		
•	01305			ADD	A*W(FBESSEL+3)*SKIP	01314	20130	01051		
•	01306			JP	B0THNEG2	01315	61000	01325		
•	01307			JP	N0FL02*AP0S	01316	60600	01210		
•	01310			SEL	CL*W(KEY)	01317	52030	01017		
•	01311			STR	A*W(FBESSEL)	01320	15030	01046		
•	01312			ENT	Q*W(BESSEL+3)	01321	10030	01036		
•	01313			ADD	Q*1	01322	26000	00001		
•	01314			RPL	Y+Q*W(BESSEL)	01323	34030	01033		
•	01315			JP	FIX2+3	01324	61000	01214		
•	01316	B0THNEG2		ADD	A*W(FBESSEL+3)	01325	20030	01051		
•	01317			JP	N0FL02*ANEG	01326	60700	01210		
•	01320			SEL	SET*W(KEY)	01327	50030	01017		
•	01321			STR	A*W(FBESSEL)	01330	15030	01046		
•	01322			ENT	Q*W(BESSEL+3)	01331	10030	01036		
•	01323			SUB	Q*1	01332	27000	00001		
•	01324			RPL	Y+Q*W(BESSEL)	01333	34030	01033		
•	01325			JP	FIX2+3	01334	61000	01214		
•	01326	FL0TEST3		ENT	A*W(FBESSEL)*ANEG	01335	11730	01046		
•	01327			ADD	A*W(FBESSEL+4)*SKIP	01336	20130	01052		
•	01330			JP	B0THNEG3	01337	61000	01347		
•	01331			JP	N0FL03*AP0S	01340	60600	01216		
•	01332			SEL	CL*W(KEY)	01341	52030	01017		
•	01333			STR	A*W(FBESSEL)	01342	15030	01046		
•	01334			ENT	Q*W(BESSEL+4)	01343	10030	01037		
•	01335			ADD	Q*1	01344	26000	00001		

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SUNTRACK

TA STATEMENT

LI ID LABEL

CARDS

NOTES

F JKB Y

LOC

CARDS	LI ID LABEL	TA STATEMENT	LOC	F JKB Y	NOTES
•	01336	RPL Y+Q*W(BESSEL)	01345	34030 01033	
•	01337	JP FIX3+3	01346	61000 01222	
•	01340	ADD A*W(FBESSEL*4)	01347	20030 01052	
•	01341	JP N0FL03*ANEG	01350	60700 01216	
•	01342	SEL SET*W(KEY)	01351	50030 01017	
•	01343	STR A*W(FBESSEL)	01352	15030 01046	
•	01344	ENT Q*W(BESSEL*4)	01353	10030 01037	
•	01345	SUB Q*1	01354	27000 00001	
•	01346	RPL Y+Q*W(BESSEL)	01355	34030 01033	
•	01347	JP FIX3+3	01356	61000 01222	
•	01350	LSH AQ*29D	01357	07000 00035	
•	01351	SEL SET*W(KEY)	01360	50030 01017	
•	01352	JP ST0R1	01361	61000 01120	
•	01353	LSH AQ*29D	01362	07000 00035	
•	01354	SEL SET*W(KEY)	01363	50030 01017	
•	01355	JP ST0R2	01364	61000 01137	
•	01356	LSH AQ*29D	01365	07000 00035	
•	01357	SEL SET*W(KEY)	01366	50030 01017	
•	01360	JP ST0R3	01367	61000 01160	
•	01361	LSH AQ*29D	01370	07000 00035	
•	01362	SEL SET*W(KEY)	01371	50030 01017	
•	01363	JP ST0R4	01372	61000 01176	
•	01364	ENTRY	01373	61000 00000	
•	01365	JP MIKE*ANEG	01374	60700 01400	
•	01366	LSH AQ*B5*QP0S	01375	07205 00000	
•	01367	ADD A*1	01376	20000 00001	
•	01370	EXIT	01377	61010 01373	
•	01371	LSH AQ*B5*QNEG	01400	07305 00000	
•	01372	SUB A*1	01401	21000 00001	
•	01373	EXIT	01402	61010 01373	
•	01374	ENTRY	01403	61000 00000	
•	01375	JP MAX*ANEG	01404	60700 01410	
•	01376	RSH AQ*B5*QP0S	01405	03205 00000	
•	01377	ADD A*1	01406	20000 00001	
•	01400	EXIT	01407	61010 01403	
•	01401	RSH AQ*B5*QNEG	01410	03305 00000	
•	01402	SUB A*1	01411	21000 00001	
•	01403	EXIT	01412	61010 01403	
•	01404	YRREMAIN	01413	00000 00000	
•	01405	WHOLEYEAR	01414	00000 00000	

ENTER WITH B5 SET TO SHIFTS

ENTER WITH B5 SET TO SHIFTS

CARDS	LI	ID	LABEL	TA	STATEMENT	LUC	F	JKB	Y	NOTES
*	01406		JULIANDAY	0		01415	00000	00000	00000	
*	01407		IMPERIAL	0		01416	00000	00000	00000	
*	01410		TAPEBLØCK	0		01417	00000	00000	00000	
*	01411		SLØTBLØCK	0		01420	00000	00000	00000	
*	01412		TAPESEARCH	0		01421	00000	00000	00000	
*	01413		RAAD	0		01422	00000	00000	00000	
*	01414		DECAD	0		01423	00000	00000	00000	
*	01415		DISTAD	0		01424	00000	00000	00000	
*	01416		RADIFAD	0		01425	00000	00000	00000	
*	01417		DECIDIFAD	0		01426	00000	00000	00000	
*	01420		DISTDIFAD	0		01427	00000	00000	00000	
*	01421		SAFE	0		01430	00000	00000	00000	
*	01422		AEPHEM	RESERVE	8630	01431	00000	00000	00000	
*	01423		LASTEPHEM	0		03170	00000	00000	00000	
*	01424			RESERVE	1	03171	00000	00000	00000	
						03172	00112	30264		
						03173	00112	32007		
						03174	31050	00005		

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2. Explanatory Supplement to the Astronomical Ephemeris and the American Ephemeris and Nautical Almanac (Her Majesty's Stationery Office, London, 1961).
3. R. Butler and E. Kerr, An Introduction to Numerical Methods (Sir Isaac Pitman and Sons, Ltd., London).

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13. ABSTRACT

This memorandum describes the method used by the Haystack pointing computer program for obtaining the celestial coordinates of the SUN at any time.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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